Atmospheric Dynamics II

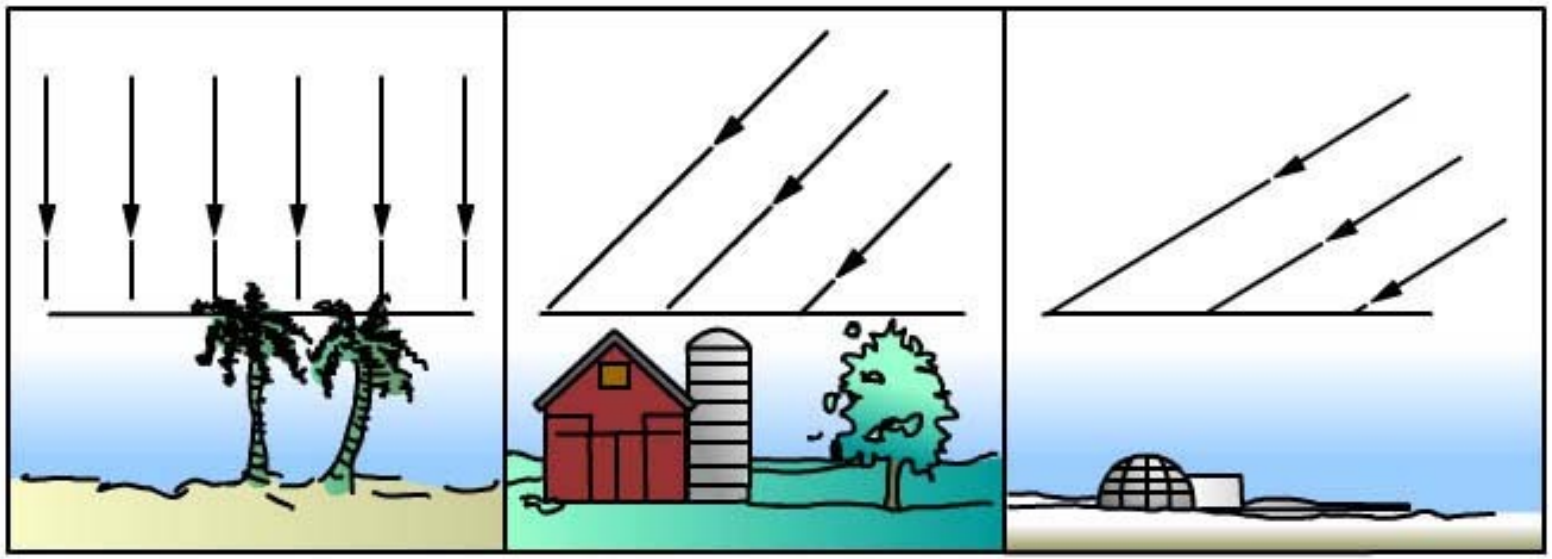
Determine the formation and characteristics of specific air-masses and describe how they are modified after leaving their source region.

Climatic Controls

- Definition: Relatively permanent factors governing general nature of earth's climate.
  - Major factors controlling large-scale climate include latitude, distribution of continent/oceans, topography, ocean currents

Climatic Controls

- Latitude
  - Variations of insolation make latitude most important climatic control
  - Generally higher temperatures at low latitudes, lower temperatures at high latitudes


LOW LATITUDES
LOW < OF INCIDENCE
MIDDLE LATITUDES
HIGH LATITUDES
HIGH < OF INCIDENCE

Climatic Controls
LATITUDE

- Has greatest influence on global distribution of temperature.
  - Temperatures shift with season
  - Inclination of earth's' axis with respect to orbit essentially reason for seasonal shift
  - Northern Hemisphere (NH) and Southern Hemisphere (SH) receive varying amounts of sunlight as they tilt toward or away from the sun during the orbital cycle.

Climatic Controls

- Summer Solstice
  - » NH (SH) tilts most directly toward (away from) the sun
  - » Longest (shortest) day in the NH (SH) with 24 hour daylight (darkness) poleward of the Arctic (Antarctic) circle at 66.5°N (66.5°S)
  - » NH (SH) noonday sun angle is highest (lowest) in the sky as the sun's rays are vertical to the earth's surface at the Tropic of Cancer at 23.5°N.
  - » First day of summer (winter) in NH (SH)

Climatic Controls

- Winter Solstice
  - » NH (SH) tilts most directly away from (toward) the sun.
  - » Shortest (longest) day in the NH (SH) with 24 hour darkness (daylight) poleward of the Arctic (Antarctic) circle at 66.5°N (66.5°S)
  - » NH (SH) noonday sun angle is lowest (highest) in the sky as the sun's rays are vertical to the earth's surface at the Tropic of Capricorn at 23.5°S.
  - » First day of winter (summer) in the NH (SH)

Climatic Controls

- Spring (Vernal) Equinox
  - » Both the NH and SH receive the same amount of sunlight
  - » Days and nights are 12 hours long everywhere in both the NH and SH.
  - » The sun's rays are vertical to the earth's surface at the Equator
  - » First day of spring (fall) in the NH (SH) aaas sun's most direct rays are in transition from the SH to the NH.

Climatic Controls

- Fall (Autumnal) Equinox
  - » Both the NH and SH receive the same amount of sunlight
  - » Days and nights are 12 hours long everywhere in both the NH and SH.
  - » The sun's rays are vertical to the earth's surface at the Equator.
  - » First day of fall (spring) in the NH (SH) as sun's most direct rays are in transition from the NH to the SH

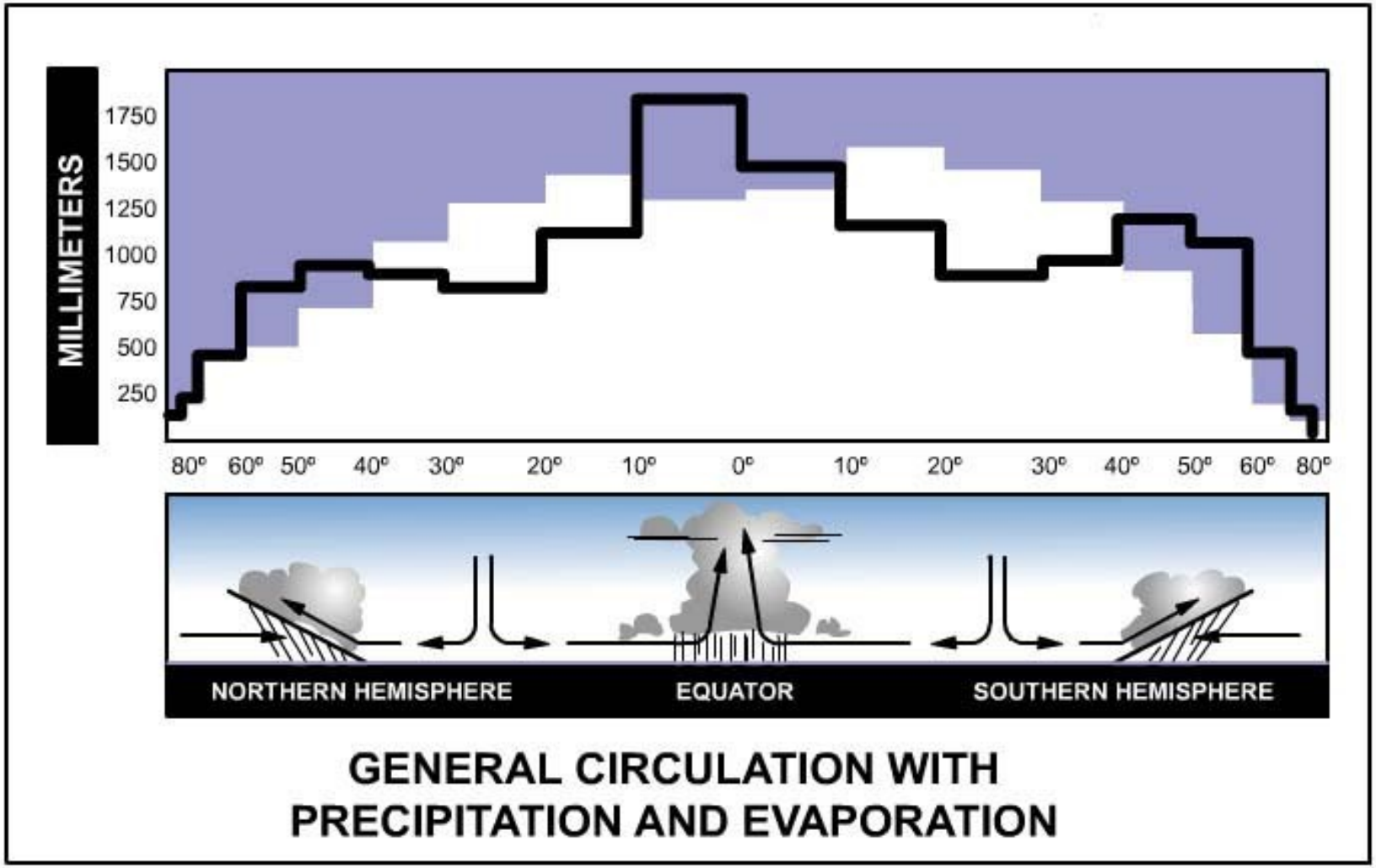
Climatic Controls

THERMAL LAG

- Highest (lowest) temperatures lag behind the summer (winter) solstice by 30 to 45 days due primarily to the very large specific heat of the oceans and snow/ice feedback processes.

Climatic Controls
LATITUDE

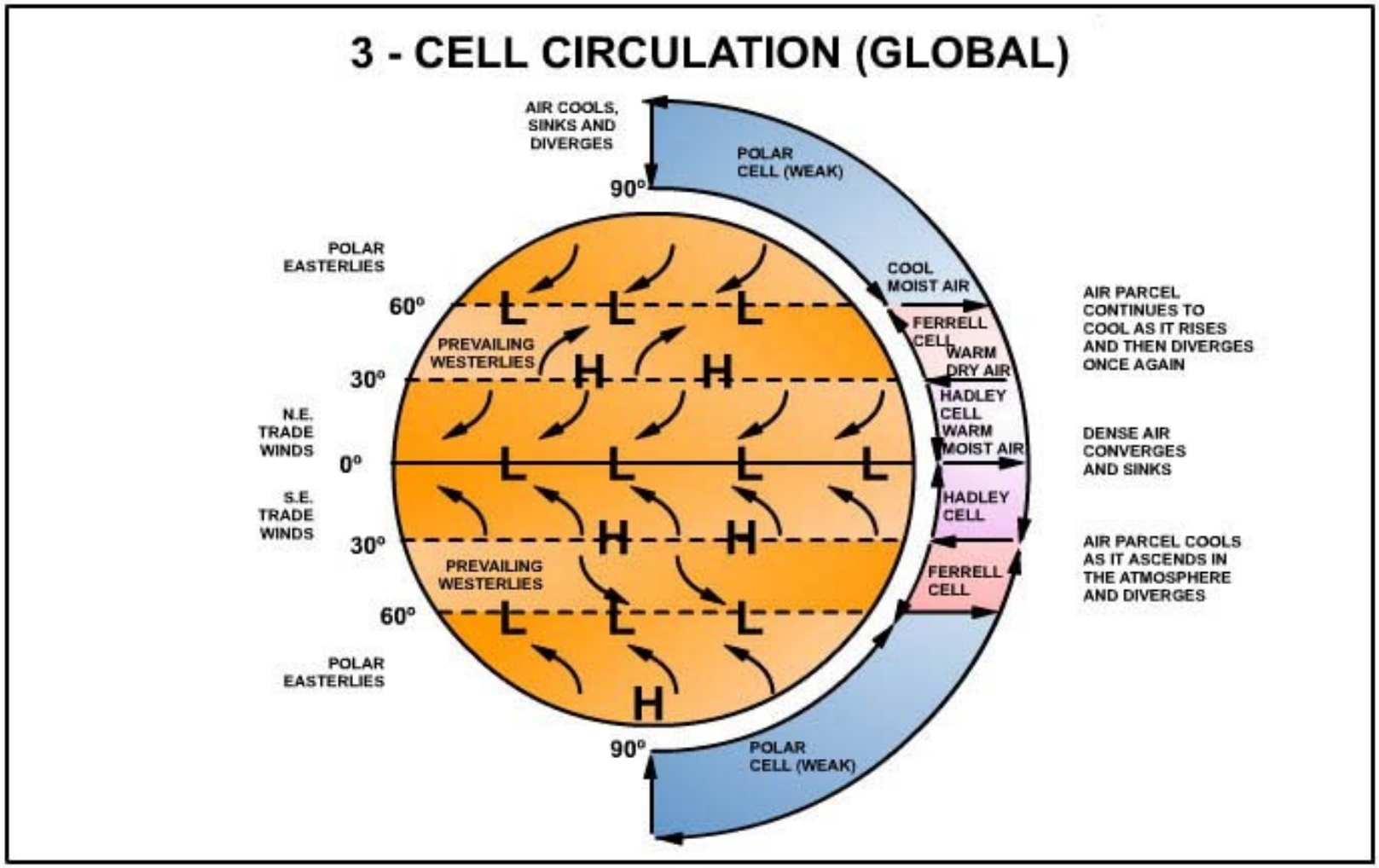
- Influences moisture/precipitation
  - Equatorial regions receive more precipitation than polar regions.
  - Due, in part, to global temperature distribution



GENERAL CIRCULATION WITH
PRECIPITATION AND EVAPORATION

Climatic Controls
LATITUDE

- Influences Location of Semi-permanent Pressure Systems
  - General circulation of atmosphere is average flow of air over entire globe. Transports warm air poleward, cold air equatorward


3 - CELL CIRCULATION (GLOBAL)
AIR COOLS, SINKS AND DIVERGES
POLAR CELL (WEAK)
90°
POLAR EASTERLIES
60°
PREVAILING WESTERLIES
30°
N.E. TRADE WINDS
0°
S.E. TRADE WINDS
30°
PREVAILING WESTERLIES
60°
POLAR EASTERLIES
90°
POLAR CELL (WEAK)
COOL MOIST AIR
FERRELL CELL
WARM DRY AIR
HADLEY CELL
WARM MOIST AIR
HADLEY CELL
FERRELL CELL
AIR PARCEL CONTINUES TO COOL AS IT RISES AND THEN DIVERGES ONCE AGAIN
DENSE AIR CONVERGES AND SINKS
AIR PARCEL COOLS AS IT ASCENDS IN THE ATMOSPHERE AND DIVERGES

Climatic Controls

- Three Cell Theory (as introduced in Dynamics I)
  - Hadley (Equator - 30^{o} N/S)
    - » Thermally direct circulation
  - Ferrell (30^{o} - 60^{o} N/S)
    - » Thermally indirect circulation
  - Polar (60^{o} N/S - Poles)
    - » Thermally direct dirculation
- Latitudinal differential heating in combination with earth's rotation controls formation.

Climatic Controls

- Equatorial Trough - belt of low pressure at surface
  - Located between 10^{o} N/S
  - Easterly trades from both hemispheres converge toward the low pressure
  - Warm, moist region of rising air with heavy precipitation.
  - Also known as the Inter-Tropical Convergence Zone (ITCZ)
  - Diverging air in upper troposphere moves poleward
  - Results from intense heating of tropics

Climatic Controls

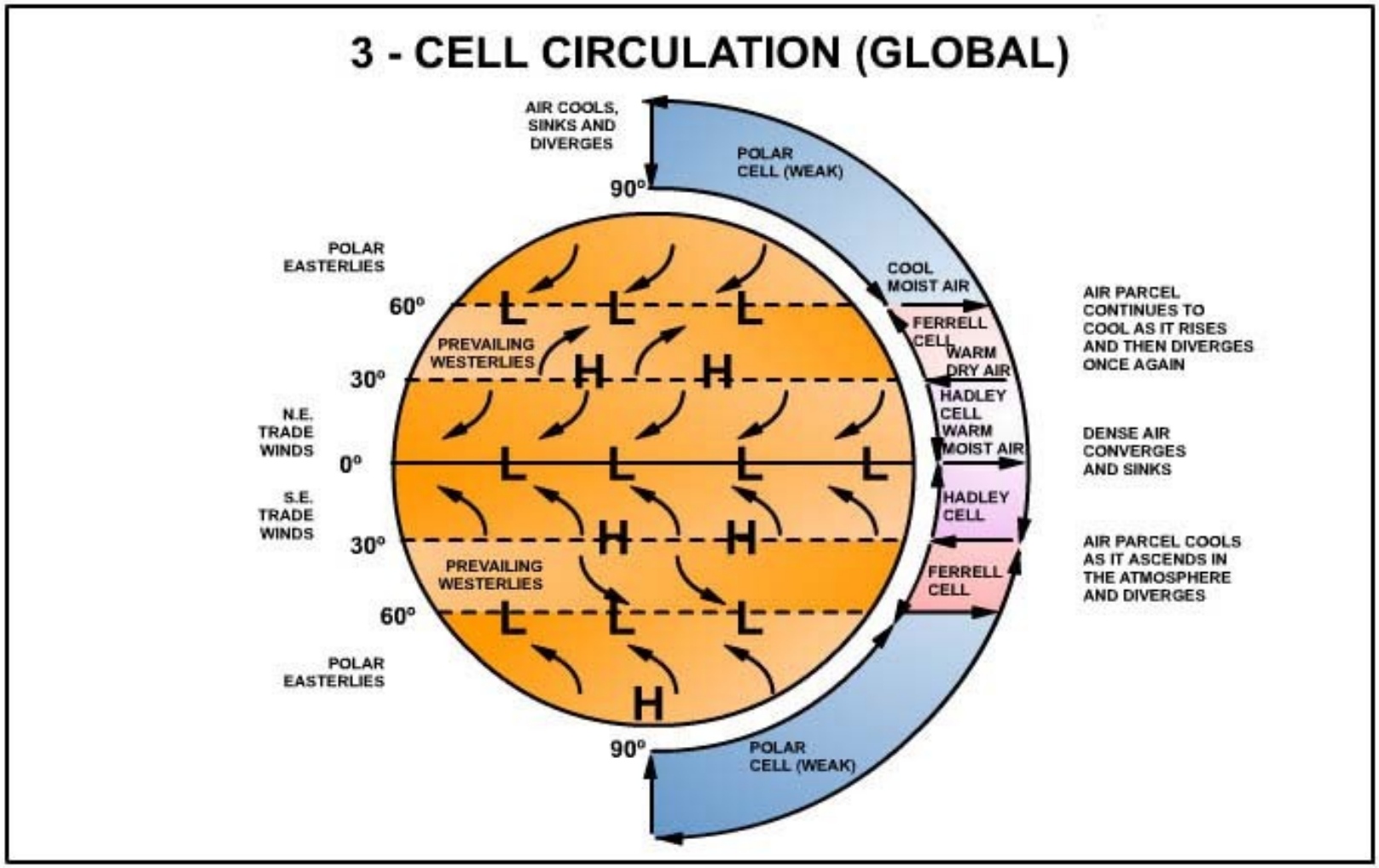
- Subtropical Highs
  - Located near 30º N/S
  - Diverging winds separate easterly trade winds from prevailing westerlies
  - Warm, dry region of sinking air
  - Desert belt

Climatic Controls

- Subpolar Lows
  - Located near 60º N/S
  - Polar easterlies/prevailing mid-latitude westerlies converge toward zone of low pressure associated with the polar front.
  - Very stormy with extensive regions of precipitation.
  - Lifting and divergence aloft associated with the polar front and jet stream

Climatic Controls

- Polar Highs
  - Develop near poles
  - Result of convergence aloft of polar cells
  - Arctic High (NH) strongest in winter


3 - CELL CIRCULATION (GLOBAL)
AIR COOLS, SINKS AND DIVERGES
POLAR CELL (WEAK)
90°
POLAR EASTERLIES
60°
PREVAILING WESTERLIES
30°
N.E. TRADE WINDS
0°
S.E. TRADE WINDS
30°
PREVAILING WESTERLIES
60°
POLAR EASTERLIES
90°
POLAR CELL (WEAK)
COOL MOIST AIR
FERRELL CELL
WARM DRY AIR
HADLEY CELL
WARM MOIST AIR
HADLEY CELL
FERRELL CELL
AIR PARCEL CONTINUES TO COOL AS IT RISES AND THEN DIVERGES ONCE AGAIN
DENSE AIR CONVERGES AND SINKS
AIR PARCEL COOLS AS IT ASCENDS IN THE ATMOSPHERE AND DIVERGES

Climatic Controls

- Semi-permanent pressure systems influence climatic elements
  - Determine prevailing winds
  - Influence temperature advection, atmospheric stability, and availability of moisture

Climatic Controls

- Distribution of Continents/Oceans
  - Influence on temperature: Second in importance only to latitude as control of temperature
  - Influence on moisture: All phenomena connected with atmospheric moisture, related to distribution of land/water

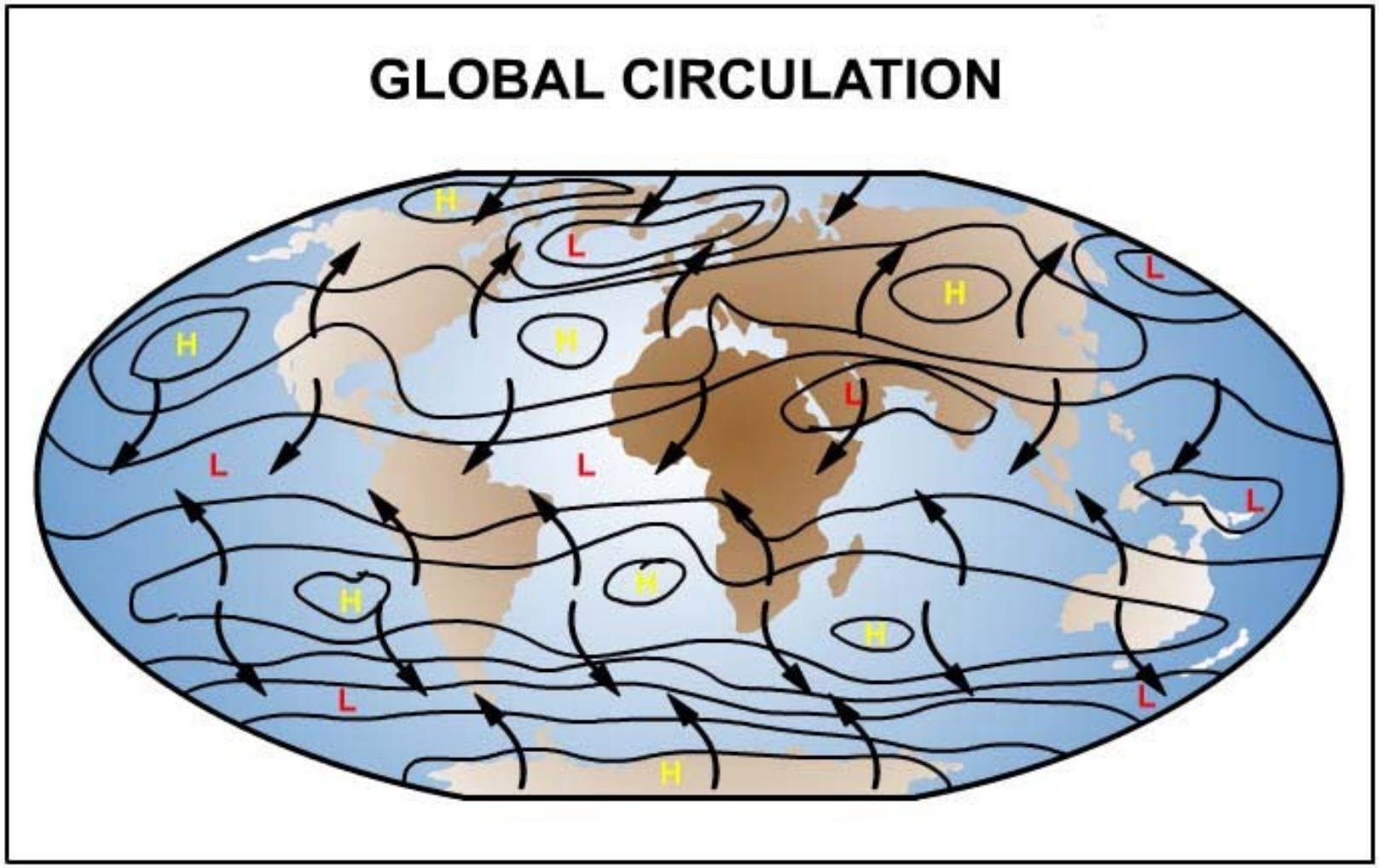
Climatic Controls

Distribution of Continents/Oceans

- Influence on general circulation pattern - breaks up belts of semi-permanent high and low pressure systems in mid-latitudes

  Examples

  - Intense high pressure over Siberia in winter
    - Radiational cooling of land under mostly clear skies and little if any solar radiation.
    - Upper tropospheric convergence and subsidence promoted by favorable jet stream and Rsosby wave pattern west of large oceans in mid/high latitudes.


GLOBAL CIRCULATION
H
L
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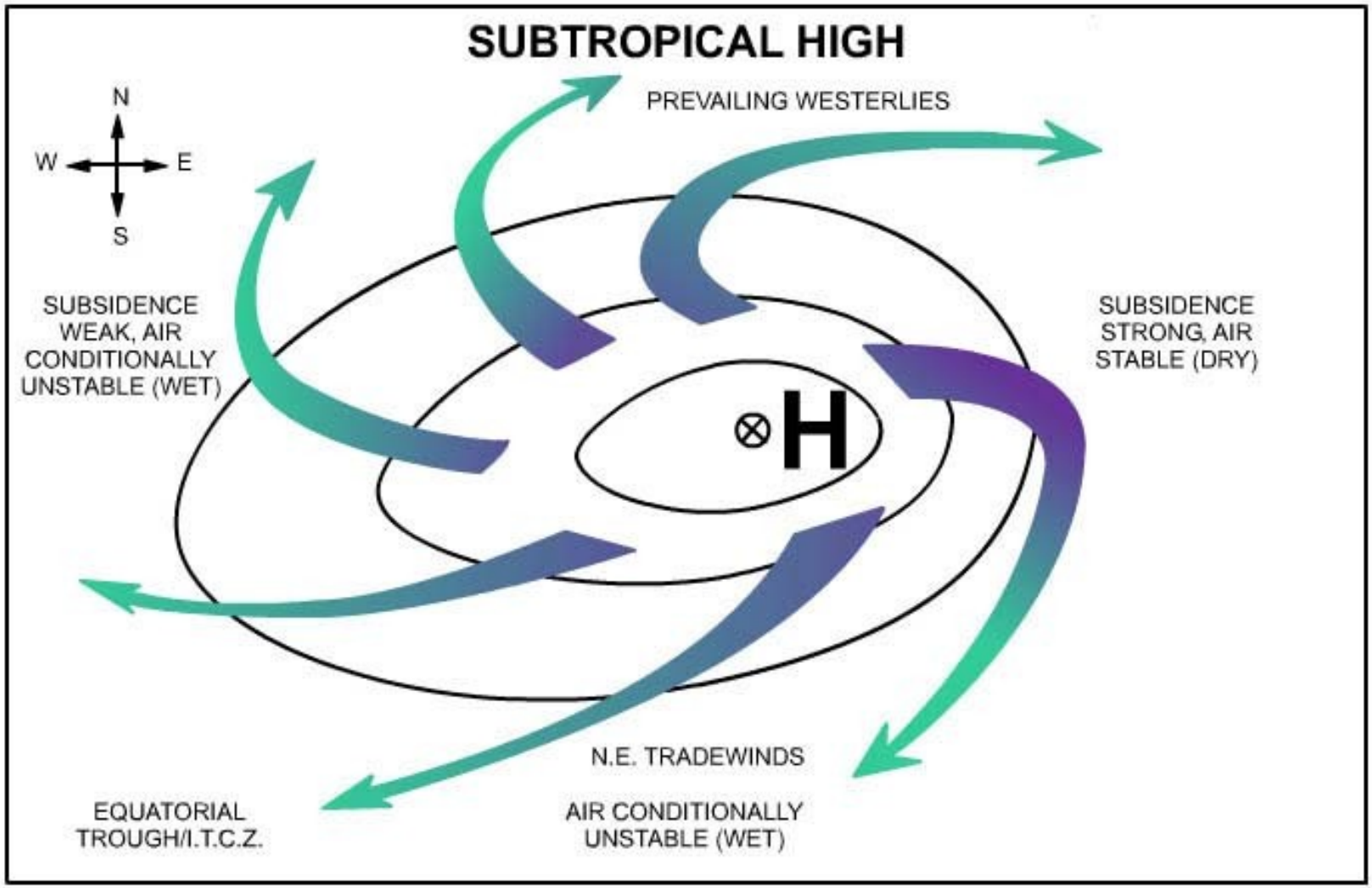
H
L
H
L
L
L
H
H
H
L
L

Climatic Controls

SEMIPERMANENT PRESSURE SYSTEMS

- Subtropical Highs
  - North Pacific High
  - North Atlantic (Bermuda) High
  - Prevailing winds, temperature advection, availability of moisture, and atmospheric stability differ from one side of the subtropical high to the other.


SUBTROPICAL HIGH
N
W
E
S
PREVAILING WESTERLIES
SUBSIDENCE
WEAK, AIR
CONDITIONALLY
UNSTABLE (WET)
SUBSIDENCE
STRONG, AIR
STABLE (DRY)
H
N.E. TRADEWINDS
EQUATORIAL
TROUGH/I.T.C.Z.
AIR CONDITIONALLY
UNSTABLE (WET)

Climatic Controls

- Subpolar lows best developed at higher latitudes over open oceans during wintertime.
  - Aleutian Low (North Pacific)
  - Icelandic Low (North Atlantic)
  - Development aided by:
    - » Available moisture and relative warmth of ocean (compared to continents) at that latitude, reducing stability of atmosphere..
    - » Upper-tropospheric divergence and lifting promoted by favorable jet stream and Rossby wave pattern east of large continents.

Climatic Controls

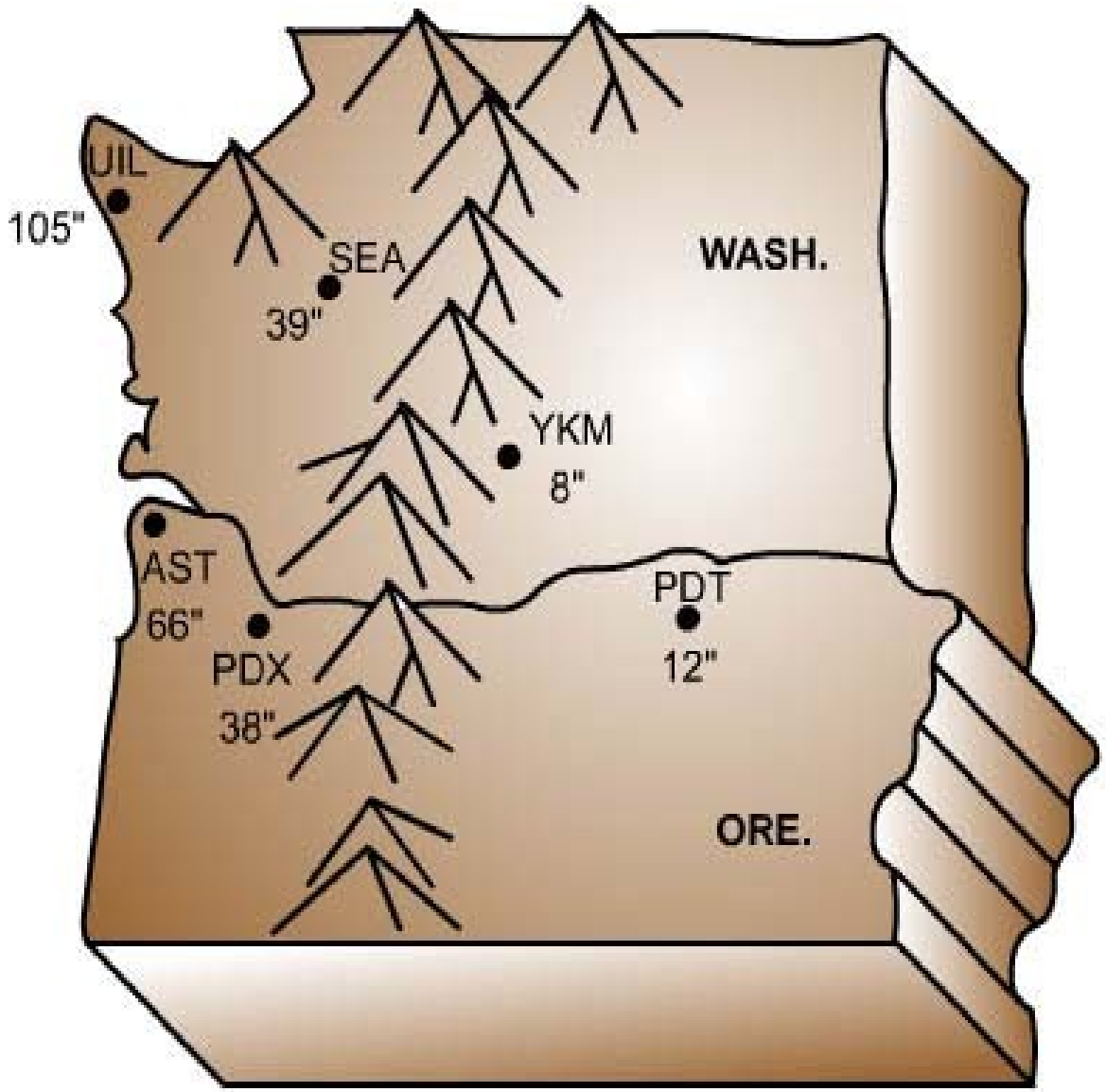
- Large-scale topography and elevation
  - Modifies other climatic controls

Climatic Controls

- Large-scale topography and elevation
  - Mountain range oriented parallel to prevailing winds
    - May not greatly modify climate

Climatic Controls

- Mountains perpendicular to prevailing winds
  - Greater effect on modifying climate, particularly downstream of mountains.
  - Windward ascension
    - Adiabatically cool, condense
    - Abundance of cloudiness/precipitation
  - Leeward descension - Adiabatically warms, dries


UIL
105"
SEA
39"
WASH.
YKM
8"
AST
66"
PDX
38"
PDT
12"
ORE.

Climatic Controls

- Mountains acting as regions of elevated heating under intense solar radiation.
  - Elevated heating of large mountain ranges during summer promotes synoptic-scale low pressure development and extensive circulation changes throughout the troposphere.

Climatic Controls

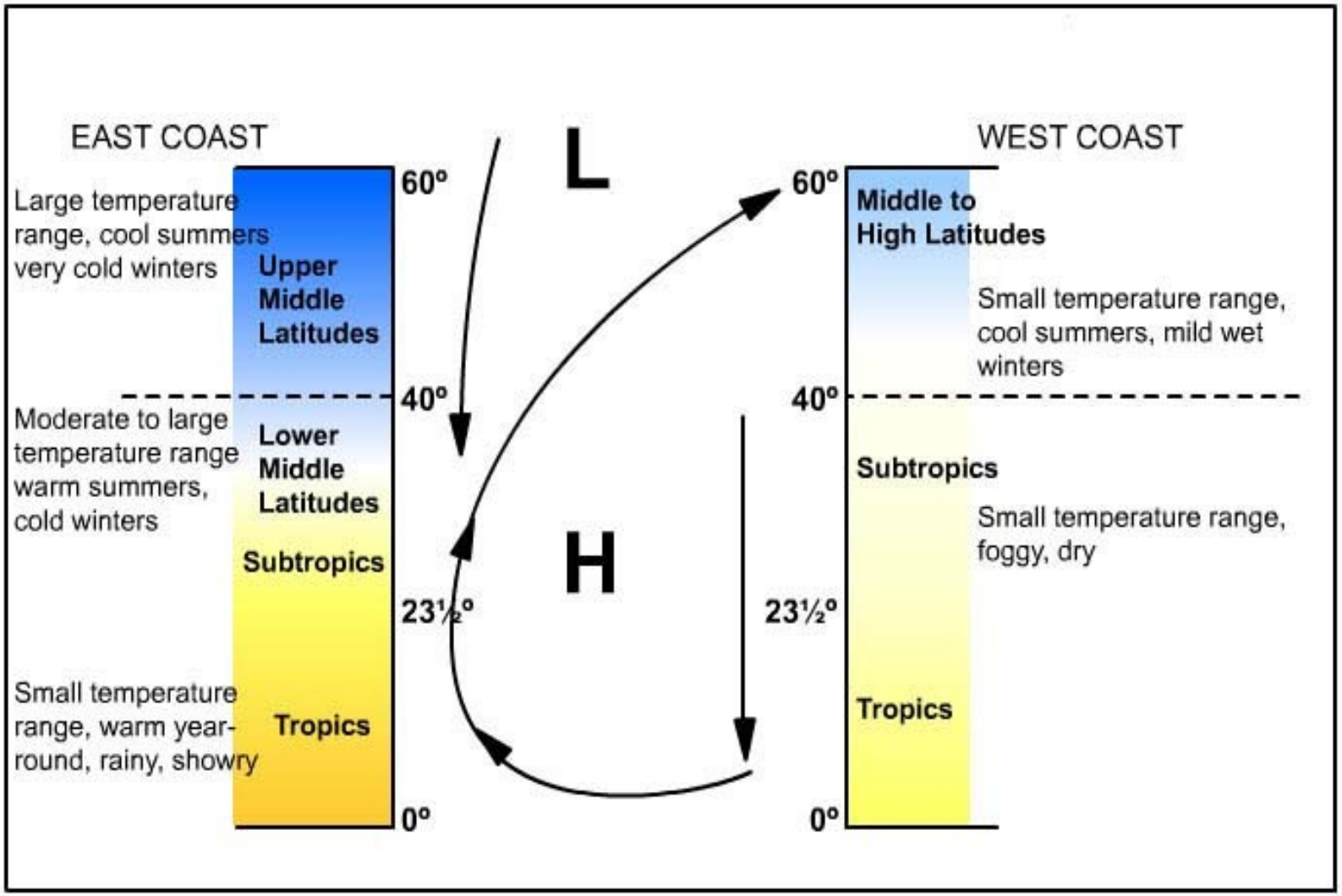
- Ocean Currents
  - Causes
    - Primary - frictional effects of winds around semi-permanent pressure systems. Tend to follow flow patterns
      - Warm currents on east coasts, cold on west coasts
      - Definite effect on coastal climates as well as air masses and pressure systems transiting them

Climatic Controls
OCEAN CURRENTS

- Influence on climate
  - » Greatest downstream, small influence upstream
  - » Storms enhanced over warm currents.

    Mid-latitudes: Polar front cyclones favor sharp temperature gradients between cold and warm surfaces (i.e., cold and warm water or cold land and warm water.

    Tropics: Hurricanes favor warm water.
  - » Storms generally suppressed over cold currents.


EAST COAST
WEST COAST
L
H
60°
40°
23½°
0°
Large temperature range, cool summers very cold winters
Upper Middle Latitudes
Moderate to large temperature range warm summers, cold winters
Lower Middle Latitudes
Subtropics
Small temperature range, warm year-round, rainy, showry
Tropics
Middle to High Latitudes
Small temperature range, cool summers, mild wet winters
Subtropics
Small temperature range, foggy, dry
Tropics

Climatic Controls

» Western coastlines (between 20° and 40°)

Bordered by cold upwelling currents

Small diurnal/annual temperature ranges

Periodic precip during winter as storms migrate further south. Dry summers.

» West coasts (between 40° and 60°)

Bordered by relatively warm currents

Summers cool, winters mild/wet

Small annual temperature ranges

Climatic Controls

- Eastern seaboards (between 20° and 40°)

  Bordered by warm currents

  Moderate temperature ranges, warm temperatures

  Frequent showery precipitation due to greater thermal instability promoted by warmer air temperatures and higher dew points.

Climatic Controls

- East coasts (between 40° and 60°)
  - Bordered by cold currents
  - Winters very cold, summers cool
  - Large annual temperature ranges
  - Frequently affected by storms tracking off-shore

Climatic Controls

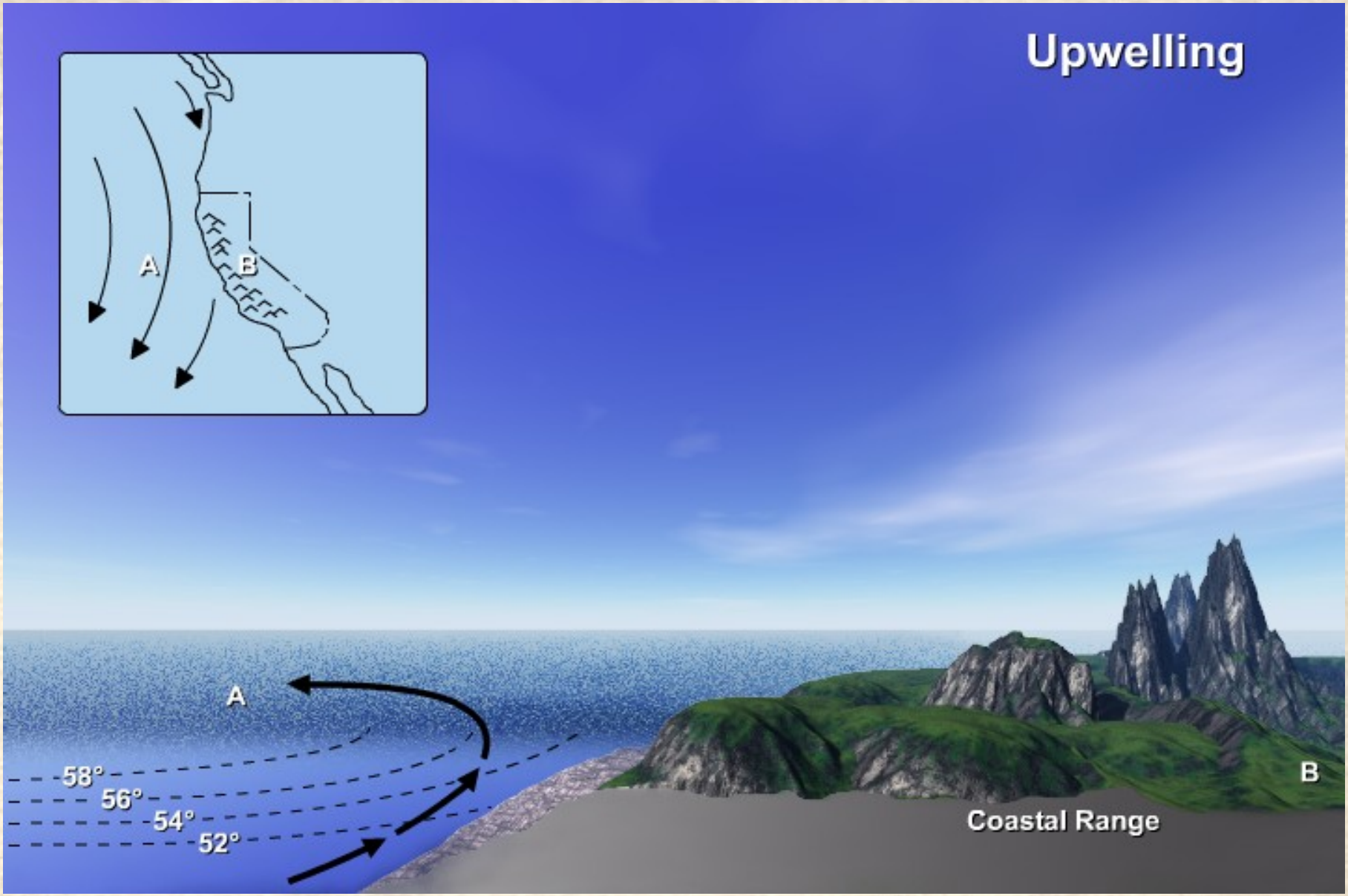
- Upwelling

  process by which colder subsurface waters rise to ocean surface

Climatic Controls

UPWELLING

- Associated weather
  - » Coast - Cool/damp with very high relative humidity but low dew points.
  - » Coast - Fog/stratus with little/no precipitation because of enhanced stability.
  - » Inland - hot/dry with very low relative humidity as air temperature rises, but dew point stays low.


Upwelling
A
B
A
58°
56°
54°
52°
B
Coastal Range

Air masses

- Air mass: A widespread body of air with similar (homogeneous) temperature and moisture characteristics in any horizontal direction at any selected altitude (most relevant in the lower troposphere).

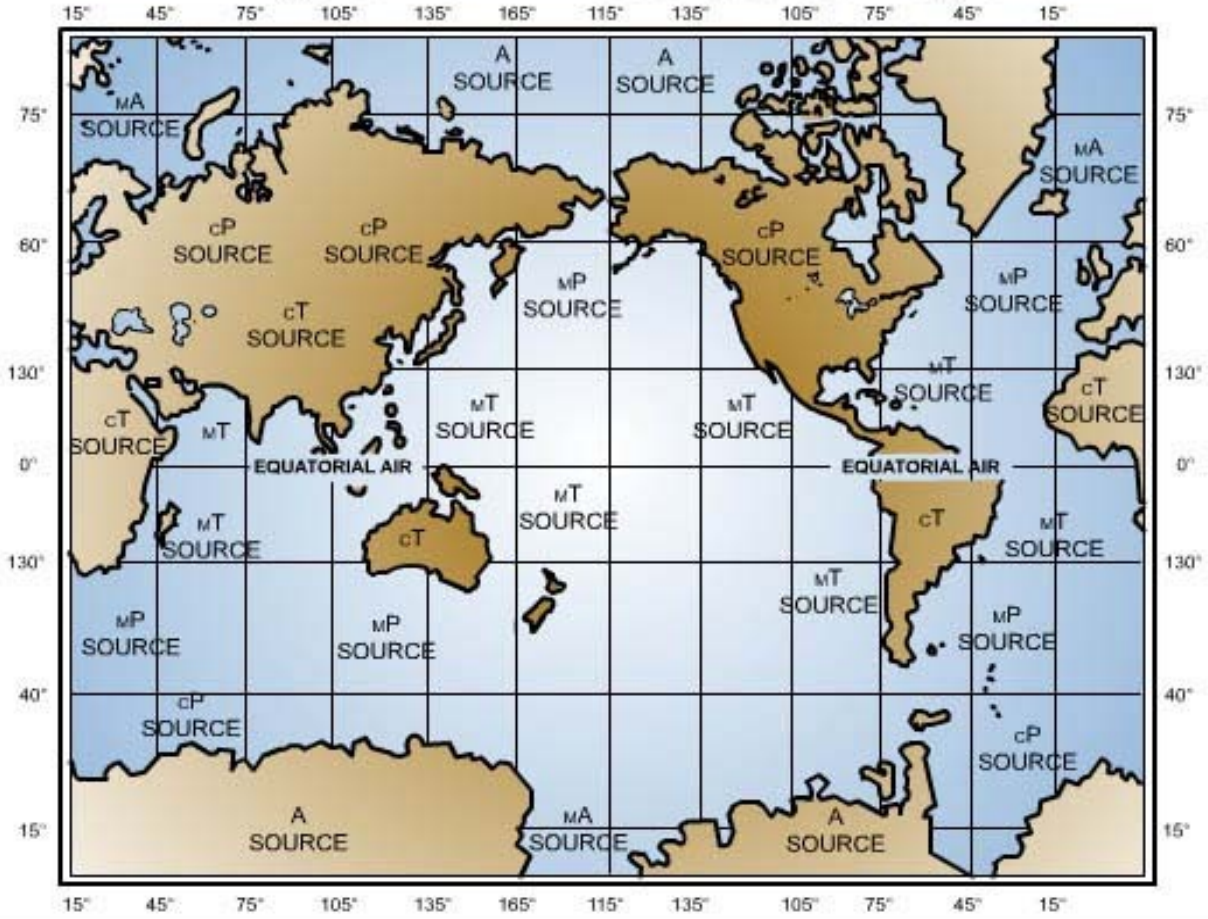
Air masses

- Air mass source region: A large area of generally level terrain, light winds, and uniform temperature and moisture characteristics usually located outside of the middle latitudes.

Air masses

- Source regions may undergo large seasonal variations in size due to changes in shortwave and longwave radiational budgets. Some source regions are only active in certain seasons.

Figure 1-9 Air Mass Source Regions



Classification of air masses

- (Geographical) Source Region Indicator:

  Area where air mass acquired its temperature properties.

  – Arctic/Antarctic (A): implies very cold.

  – Polar (P): implies cold to cool.

  – Tropical (T): implies warm to hot.

Classification of air masses

- Moisture indicator: Area where air mass acquired its moisture properties.
  - Maritime (m): implies moist (of oceanic origin).
  - Continental (c): implies dry (of continental origin).

Classification of air masses

- Stability is normally not a good indicator of air mass type because stability within the same air mass may fluctuate from place to place.

Classification of air masses

- Surface below.
  - A surface colder than the overlying air mass may make the air mass more stable
  - A surface warmer than the overlying air mass may make the air mass unstable.

Air masses

- Air mass modifications: An air mass that is changing properties as:
  - the air mass moves over a surface of different moisture and temperature characteristics and begins to acquires these traits.
  - the air mass is forced to rise and/or sink due to terrain influences, such as mountain ranges.

Air mass Source regions and associated pressure systems.

- Continental Polar (cP)
  - Source regions - Canada, Alaska, Siberia, and sometimes Europe. Also found over frozen oceans, such as the Arctic Ocean, where moisture transfer from the ocean is inhibited by the ice cover.

Air mass Source regions and associated pressure systems

- Associated with polar high pressure systems - over land or frozen oceans which intensify in winter and weaken in summer (e.g., Canadian High, Siberian High).
- General characteristics: Cold and dry. Very stable in its source region.

Air mass Source regions and associated pressure systems

- Winter characteristics
  - Dry
  - Cold (below freezing, and many times < 0˚F) in source region.
  - Strong surface based inversion often observed in source region (stable).
  - Clear skies predominate.

Air mass Source regions and associated pressure systems

- Summer characteristics
  - Relatively low temperatures, but generally >32˚F in source region, except over ice and snow.
  - Relatively low dew points give dry character to air mass.

Air mass Source regions and associated pressure systems

- Continental Arctic (cA)
  - Source regions - Greenland, northern parts of Siberia, Alaska and Canada in winter, and Antarctica (late Fall, Winter, early Spring only).
  - Characteristics
    - An extreme form of cP air mass.
    - Normally shallow, extremely cold and extremely dry. Generally extremely stable in its source region.

Air mass Source regions and associated pressure systems

cA

- Produced by extreme radiational cooling over continental snow packs during winter. Long periods of clear skies promote its development.

Air mass Source regions and associated pressure systems

cA:

– Associated with extremely cold Canadian High and Siberian High events.

Air mass Source regions and associated pressure systems

- Eastern sides of cA high pressure systems in polar regions often reside beneath extremely low heights of isobaric surfaces on the western side of deep troughs. These low heights within the upper level trough are indicative of very cold air in the lower troposphere. When these low heights overlay cA air near the surface, extremely low 1000-500 mb thicknesses are observed.

Air mass Source regions and associated pressure systems

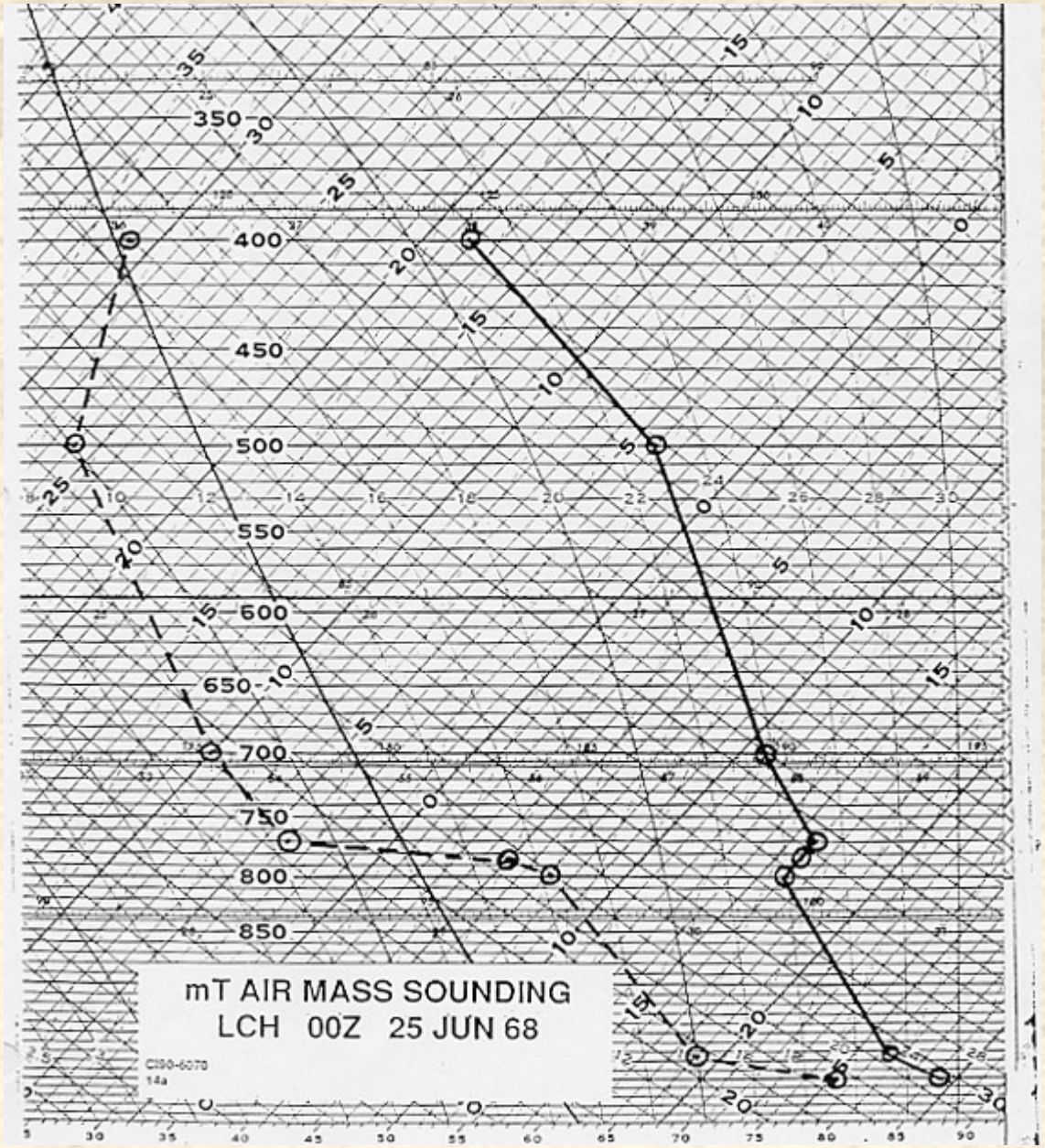
- The center of a cA high pressure system in polar regions often does not reside under the lowest 1000-500 mb thickness. Yet, the coldest surface temperatures are generally found near the high's center, where radiational cooling is maximized.

Air mass Source regions and associated pressure systems

Sharp inversions in the lower troposphere are often associated with (1) extreme radiational cooling of the surface during the polar night and (2) compressional warming aloft due to subsidence.

Air mass Source regions and associated pressure systems

- Maritime Tropical mT
  - Source regions - tropical and subtropical oceans.
  - Oceanic subtropical high pressure systems reside within the mT source region (e.g., Bermuda-Azores High in the Atlantic). Trade winds are dominated by mT air mass.


mT AIR MASS SOUNDING
LCH 00Z 25 JUN 68

Air mass Source regions and associated pressure systems

- mT
- General characteristics: Very warm and moist in low levels.
  - Subsidence, and associated subsidence inversion, prevents distribution of moisture to high levels (eastern portion and within most of the trade winds). However, weather systems or terrain may weaken or destroy this inversion, allowing mT air to locally moisten the mid and upper troposphere through convection.
  - Typically associated with dew-point temperatures $\geq$ 60˚F

Air mass Source regions and associated pressure systems

- The northeast and southeast trade winds advect mT air from the subtropical highs of each hemisphere into the equatorial ITCZ.
  - Convergence of trade winds along the ITCZ lifts the mT air, producing thunderstorms and very moist conditions throughout much of the troposphere.

Air mass Source regions and associated pressure systems

- Maritime Polar (mP)
  - Source regions - cold unfrozen ocean areas generally poleward of 45˚N/S.
    - Source region may be farther south, particularly off the west coast of mid latitude continents, due to northerly currents and upwelling.

Air mass Source regions and associated pressure systems

- Associated with portions of high or low pressure systems which reside over relatively cold water generally poleward of the of the polar front. The mP air masses form from the modification of another air mass moving over cold ocean areas.

Air mass Source regions and associated pressure systems

- Controlling factors of mP characteristics.
  - Origin of body of air modified to mP.
    - » Modification of cP or cA air masses:

      i. A cP or cA air mass moves over a cold ocean surface.

      ii. The cP or cA air may initially be much colder than the ocean; thus, the “cool” ocean is “relatively warm” compared to the air and the ocean transfers heat and moisture to the “cold”, dry air mass. Conversion to mP then occurs.

Air mass Source regions and associated pressure systems

iii. Thermal instability is common in the lower troposphere, and steam fog and even convective snow showers may develop.

iv. Modification of a cP or cA air mass into mP may be quite rapid.(48HRS)

v. A well-defined front is often present between this mP air and tropical air masses farther equatorward..

Air mass Source regions and associated pressure systems

- Modification of mT air masses:
  - i. An mT air mass moves over a cold ocean surface.
  - ii. The mT air is initially much warmer than the ocean; thus, the “cool” ocean removes heat from the air mass.
  - iii. Thermal stability is enhanced in the lower troposphere.
  - iv. The cooling of this mT air often forces the temperature to lower to the dew point, thus producing saturated conditions with extensive sea fog.
  - v. Modification of mT to mP air mass may be gradual, and no well-defined fronts may be evident between the two air masses.

Air mass Source regions and associated pressure systems

mT:

- **Predominate air mass west of the Rocky Mountains and western Europe.**

Air mass Source regions and associated pressure systems

mT:

– General characteristics

- Cool and moist in low levels.
- Very little diurnal temperature variation.

Air mass Source regions and associated pressure systems

- Continental Tropical cT
  - Source region - subtropical deserts (summer only) or tropical dry regions.
  - Summer characteristic (hot and dry)
  - Often accompanied by shallow “heat low pressure systems”

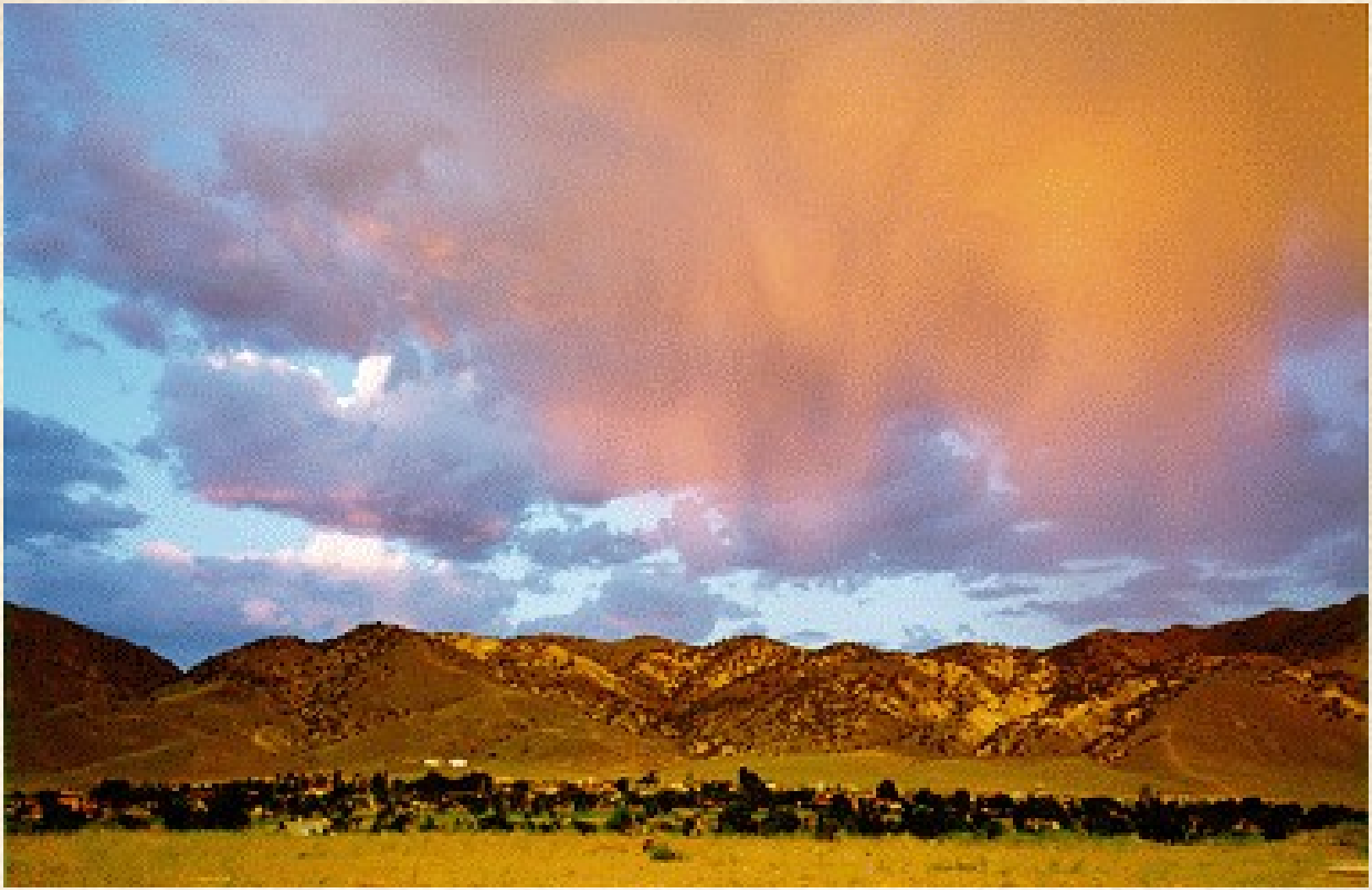
Air mass Source regions and associated pressure systems

- Unstable in low levels during the day with often a super adiabatic lapse rate, but low dew points limit cloud development.
  - Super-adiabatic lapse rate promotes thermal turbulence and dust devil formation.
- Stable during the night with a radiation inversion often observed.

Air mass Source regions and associated pressure systems

- Low and middle clouds are rare; low dew points limit cloud development.
  - Possible late afternoon Cu, TCU, CB, forming primarily near mountains (elevated heating source).
  - Usually high based. (8000-10000ft).
  - Thin, high cirrus clouds, associated with the subtropical jet stream, occur quite often in the upper troposphere over subtropical deserts.

HIGH DESERT THUNDERSTORMS WITH VIRGA



Air-mass modification

- Definitions:
  - **Thermodynamic modification**: Changes in the temperature and moisture content within the air mass
    - Implies changes to the air's density.
  - **Topography**: Major physical features on the earth's surface, particularly relating to land surface and elevation characteristics.
  - **Trajectory** (horizontal): The horizontal path described by individual parcels of air.
  - **Age of air mass**: The length of time an air mass has been removed from its source region.

Air-mass modification

- Thermodynamic modification
  - These changes occur because of:
    - Air mass contact with an underlying surface of different temperature and moisture properties.
      - The amount and rate of modification is dependent upon:
        - ⇒The magnitude of air/surface temperature and moisture differences.
        - ⇒The residence time of the air mass over the modifying surface
    - Vertical displacement of the air mass by topography or other means..

Air-mass modification

- Air colder than underlying surface
  - Air warmed from below.
  - Low-level instability.
  - Suffix with a k
- Air warmer than underlying surface
  - Air cooled from below.
  - Low-level stability.
  - Suffix with a w

Air-mass modification

- Moisture
  - Moisture added by evaporation (liquid) or sublimation (frozen) from:
    - Oceans (most important)
    - Lakes and rivers.
    - Moist ground
    - Ice and snow (very little).

Air-mass modification

- Removal of moisture by condensation (liquid), deposition (solid), and precipitation may affect stability.
  - If temperature remains constant, a decrease of water vapor will increase air mass stability.

    Example: Moist air mixing with dry air.
  - Without cooling from an external source (such a cold surface or radiational cooling), removal of water vapor through condensation or deposition will decrease stability through latent heating of the air.

    Example: Cloud formation from condensation.

Air-mass modification

- Topography
  - Mountains - amount of modification influenced by mountain orientation with respect to wind direction and mountain altitude.
    - Air masses lifted over large mountain ranges experience extreme modification.
      - » Windward side.
        i. Moisture removed through precipitation.
        ii. Stability decreases due to orographic lift (due to moisture removed during condensation).

Air-mass modification

» Leeward side:

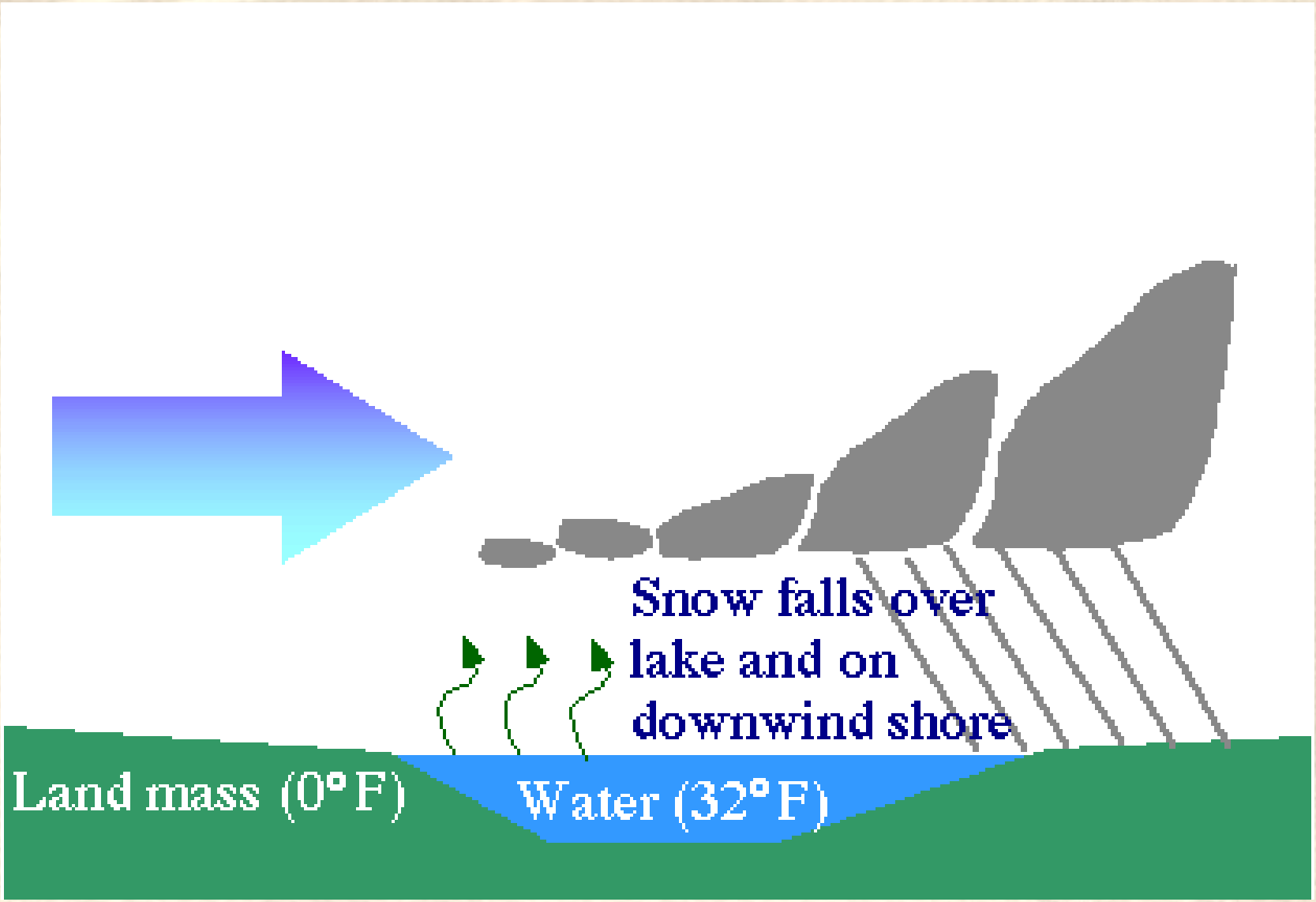
i. Air is adiabatically warmed and dried)

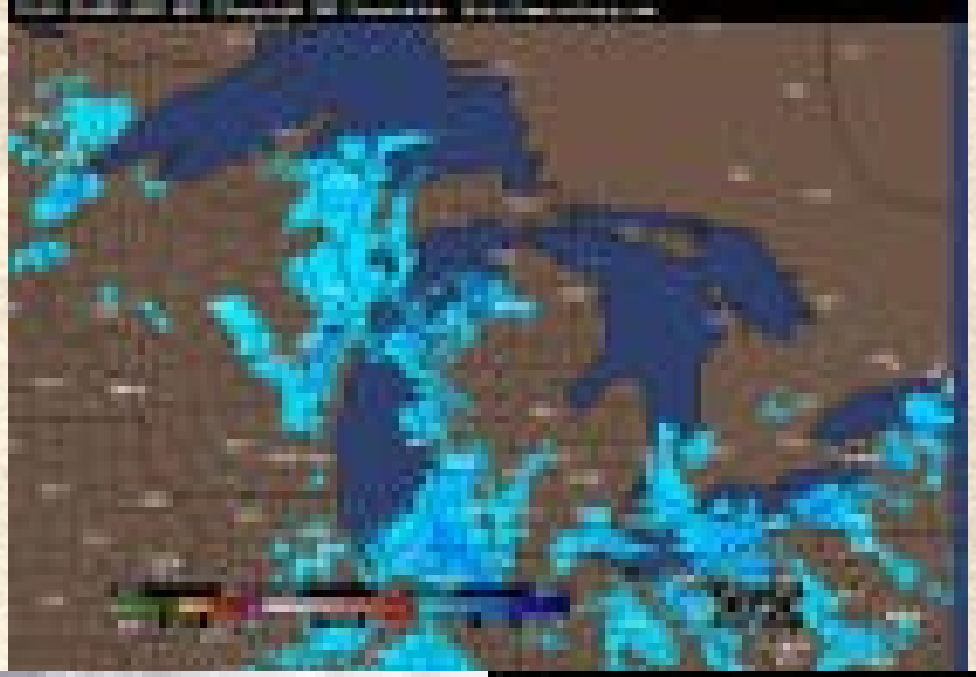
ii. Stability increases due to subsidence.

– Air masses which move parallel to mountain ranges experience little change.

Air-mass modification

- Unfrozen lakes:
  - Greatest effects generally observed on lee-side.
  - cA or cP air masses crossing large relatively warm lakes (generally in fall and early winter) will experience intense warming and moistening from below.
  - Steam fog and intense vertical mixing may result.
  - Significant RW/SW may result from the 5000 - 6000 foot tall convective clouds.


Snow falls over
lake and on
downwind shore
Land mass (0° F)
Water (32° F)



Air-mass modification

- The trajectory of air parcels is influenced by the type of surface and topography encountered, thus affecting air mass modification. However, the curvature of the trajectory may also influence the vertical motion and potentially the stability of the air mass.

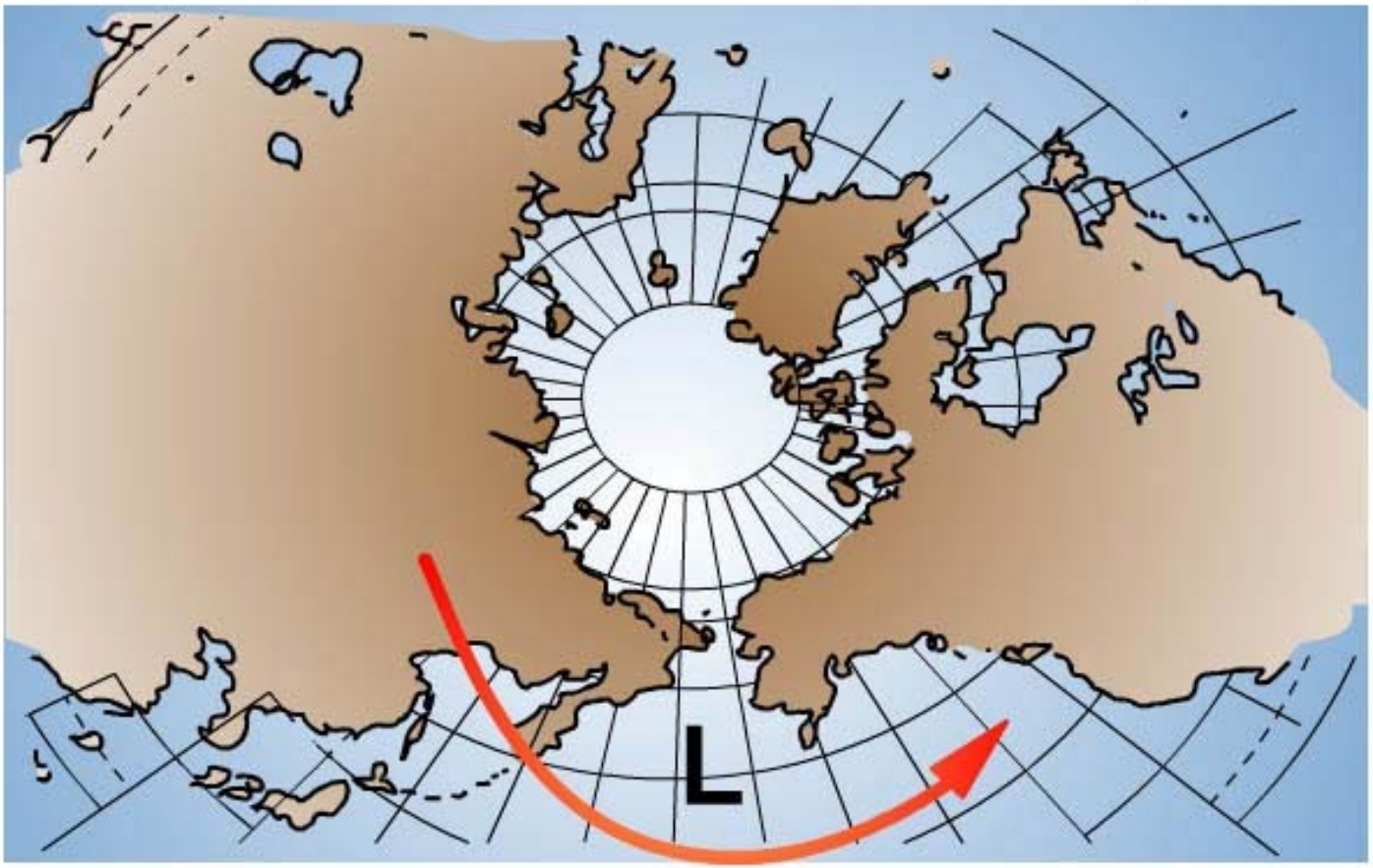


Figure 1-14: Cyclonic Trajectory

Air-mass modification

- Cyclonic trajectory:
  - Increases frictional convergence in the boundary
    - Mass convergence increases the air mass thickness (i.e., the air mass deepens).
    - Mass convergence forces ascent at the top of the boundary layer which decreases air mass stability.
  - Indicates air mass involvement with a synoptic-scale cyclone and possibly jet stream lifting mechanisms
    - Air mass is suffixed with a u

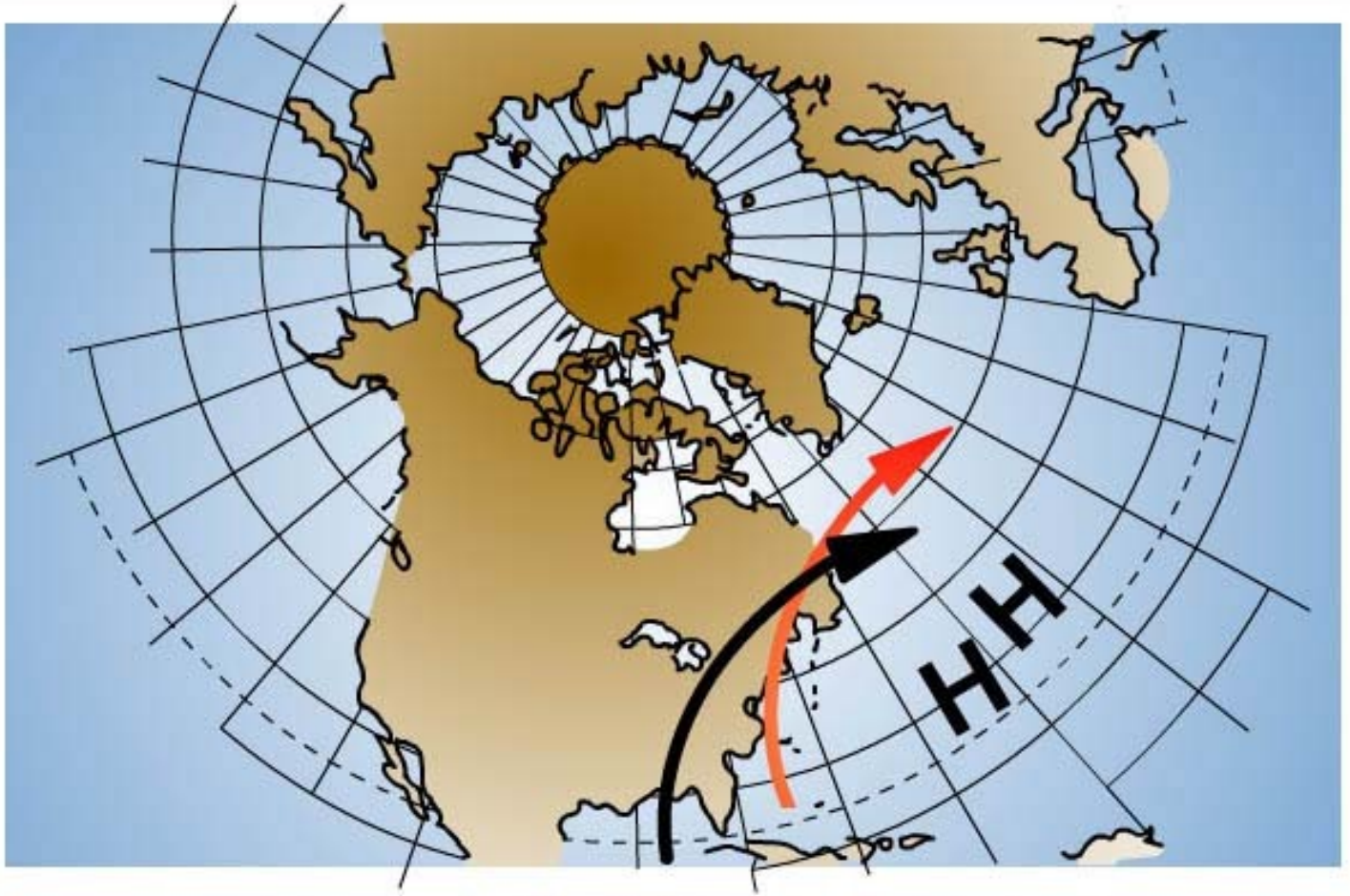


Figure 1-15: Anticyclonic Trajectory

Air-mass modification

- Anticyclonic trajectory:
  - Increases frictional divergence in the boundary layer (see Dynamics I).
    - Mass divergence decreases the air mass thickness (i.e., the air mass becomes shallower).
    - Mass divergence forces descent at the top of the boundary layer which increases air mass stability.
  - Indicates air mass involvement with a synoptic-scale anticyclone and associated jet stream subsidence mechanisms
    - Air mass is suffixed with an s

Air-mass modification

- Air mass age - The longer the air mass is away from source region, the more modification that is possible

Air-mass modification

- Selected examples of air mass characteristics as they transverse the United States during winter and summer:

Air-mass modification

⇒Example: In winter, mT air over the Caribbean Sea/gulf of Mexico source region originally displays temperatures in the 80's and dew points int the 70's. Upon transversing cool, coastal waters and colder land over the SE United States, the air mass has experienced some cooling and some loss of moisture (condensation, profducing dew and advection fog). Thus, but the time the modified mT air mass reaches Nashville, TN, temperatures and dew points have fallen to the 60's . However, compared to cP and cA air masses over other parts of the U.S., the air over Nashville appears ":warm and moist" and retains much of its mT character (in a relative sense). Meteorologists, understanding that the air originated from a mT source region, continue to label the air over Nashville as mT.

Air-mass modification

- Winter characteristics
  - cA or cP air masses
    - Dry, cold, and stable over land.
      - » Skies are usually clear at night, may have scattered flattened stratocumulus during the day.
      - » Under brisk equatorward-directed winds on the east side of the anticyclone, visibility is usually excellent.

Air-mass modification

- Excellent radiation conditions and calm winds in the center of cP and cA anticyclones produce freezes or heavy frost at night..
- Only limited modification of air mass occurs when snow cover is extensive. In extreme conditions, cA air has produced temperatures < 0°F as far south as the Gulf Coast.
- Boundary between cP or cA and mT exhibits a sharp air mass contrast along the polar front

Air-mass modification

- Rapid modification over relatively warm water.
  - » Skies rapidly become broken to overcast as steam fog moistens and warms the boundary layer and extensive decks of stratocumulus (anticyclonic flow) or cumulus (cyclonic flow) develop in unstable layer.
  - » Visibility may be reduced due to steam fog and showers.
  - » Heavy “lake-effect” snow showers may develop and significantly impact locations downwind.
- Winter cP is more stable than summer cP

Air-mass modification

- East of mountain ranges, cP or cA air may dam against the mountains instead crossing over. This Cold Air Damming of cP or cA air is common east of the Rocky Mountains and produces shallow upslope fog, drizzle, and stratiform precipitation over the Plains. In addition, a barrier jet often develops in this dammed air and accelerates the cP or cA air mass southward toward Texas and Mexico.

Air-mass modification

- mP air masses
  - Cool and moist in low levels.
  - Very little diurnal temperature variation.
  - Relatively milder temperatures in both winter and summer.
  - Wide-spread stratiform precipitation when forced to ascend along a front or in a cyclone..

Air-mass modification

- Modification as mP moves inland.
  - » Higher terrain - greater modification.
  - » mP moving across perpendicular mountains generates persistent stratiform precipitation on windward side before warming and drying on leeward side (such as across the Cascades and Rockies in the western U.S.)

    i Conditions with persistent cloudiness, drizzle, and stratiform precipitation.

    ii Subsidence on the leeward side of mountains produces warm and extremely dry conditions, thus air mass is no longer mP. Pacific mP air masses are limited to the West Coast of the U.S. because of the massive modification produced by mountains inland from the coast.

Air-mass modification

mP in Europe does not modify much - no perpendicular mountains.

» At high latitudes over flat terrain, may become true cP in roughly a week

» East of mountain ranges, mP air may dam against the mountains instead crossing over. This Cold Air Damming is common east of the Appalachian mountains and produces prolonged periods of dense fog, drizzle, and stratiform precipitation.

Air-mass modification

- mT air mass
  - Gulf states: Mild and moist with much cloudiness.
  - mT air moving over cold coastal waters or land stabilizes and saturates air, often generating extensive regions of advection fog and low stratus.
  - mT air incorporated into cyclones or fronts may result in extensive and heavy regions of precipitation.
  - mT air may become unstable and produce thunderstorms if lifted.
  - mT air slowly modifies (temperature and dew point fall) as it moves inland over cooler, relatively flat land.

Air-mass modification

- cT air mass
  - Doesn’t exist in U. S. during winter.

Air-mass modification

- Summer characteristics
  - cA or cP air masses
    - Cool and dry
    - Heating from surface produces unstable conditions in lower levels, but dryness of air mass generally limits cloud development..
    - Wide daily temperature range (40˚F - 80˚F).
    - Relieves hot/humid conditions when it moves southward.
    - Rarely reaches the southern U.S. during summer.

Air-mass modification

- mP air masses
  - Generally, the same as winter but warmer temperatures… cool and moist in low levels. .
  - Very stable in low levels. Often, water is cooler than air. Fog/stratus common due to further cooling of air by water.
  - Jet stream and subpolar low weaken and moves farther north - more stable in upper levels.
  - Summer characteristics: Same as winter but warmer temperatures.

Air-mass modification

- mT air masses
  - Hot and humid weather.
  - Convective instability produces showers and thunderstorms in:
    - » The afternoon over land
    - » The pre-dawn hours over the coastal waters
  - Convective activity is highly variable, depending on the presence of the trade wind inversion (i.e., subsidence inversion) aloft.
  - Stable stratus/stratocumulus clouds are often observed in early morning hours along the Texas Gulf coast beneath strong subsidence inversions.

Air-mass modification

- cT air masses
  - Since the southwest U.S. is a cT source region, many of its effects in the U.S. are already discussed in (4) (e).
  - Downsloping winds east of the Rockies also helps promote cT development into the southern Great Plains.
  - A sharp boundary between cT and Gulf mT air masses is often observed in the southern Plains… this boundary is known as the “dry line” and is a focus for much severe thunderstorm activity.

- APPLICATION: ST: Review Exercise 1
- EVALUATION:
  - Informal: Appraisal
  - Formal: Written Test